Teaching guide

IDENTIFICATION DETAILS

Degree:	Biotechnology
Scope	Biology and Genetics
Faculty/School:	Experimental Sciences
Course:	METABOLIC BIOCHEMISTRY
Type:	Basic Training
ECTS credits:	6
Year:	2
Code:	2021
Teaching period:	Third semester
Subject:	Biochemistry
Module:	Biochemistry and Molecular Biology
Teaching type:	Classroom-based
Language:	Spanish
Total number of student study hours:	150

SUBJECT DESCRIPTION

The course will focus on the study of the set of chemical reactions and other physico-chemical processes (metabolic routes) that take place inside uni- or multicellular organisms. These reactions form the basis of life at the molecular level and allow every cell to carry out vital processes such as nutrition or growth.

Biotechnology, understood as the application of the properties of living beings in the production of goods and services, has been used by human beings since ancient times. However, it was not until the last century that the scientific progress generated by the great development of Molecular Biology and Recombinant DNA Technology enabled man to control these processes, giving rise to the new Biotechnology. Currently, biotechnology can be defined as a science that combines life sciences and engineering for the use of organisms, cells, genes and biomolecules to solve practical problems in health, agriculture, food and other fields of social and economic

interest.

Biochemistry is the science responsible for studying the chemical constituents of living beings, the functions of these constituents and the transformations they undergo within an organism in order to obtain new structures and energy necessary for the development of life. Biochemistry is therefore defined as the study of life from a molecular point of view. As a science dedicated to the explanation of life, it occupies an important place in scientific knowledge. Their relationship with other sciences such as Cell Biology, Molecular Genetics and Microbiology does not admit any doubt that there is a close link between them. The study of this relationship allows us to understand the phenomenon of life holistically, as a whole, from a scientific and experimental point of view and to apply the knowledge achieved to fields such as health, biotechnological services, etc.

In relation to what was described in the previous paragraphs, the course will focus on the study of the set of chemical reactions, which, grouped together in the different metabolic routes to be studied, take place inside uni- or multicellular organisms. These reactions form the basis of life at the molecular level and allow every cell to carry out vital processes such as nutrition or growth. The approach to the study of these metabolic routes will be carried out from the point of view of those intended for the generation of energy in its various forms (chemical, calorific...) and which constitute the so-called cellular catabolism, and from the point of view of those that use this energy to achieve the generation of complex molecules, necessary for the maintenance, growth and development of every living cell and whose set of processes is called cellular anabolism. Special attention will be paid to regulating the activity of the enzymes that catalyze the biochemical reactions studied.

In order to ensure that the student acquires the above-mentioned knowledge, the subject has been essentially organized into theoretical classes and practical classes. With regard to theoretical classes (which will occupy most of the credits of the subject), the program has been divided into three different sections. In the first one, an introduction to cellular metabolism and its main characteristics (division between anabolism and catabolism, energy processes, energy activated metabolites...) will be carried out, in addition to analyzing the main mechanisms by which the enzymes that catalyze the various reactions of each of the metabolic routes that will be studied later are regulated. The second section (which will constitute the main body of the theoretical classes) will be dedicated to studying the metabolism of the main biomolecules: sugars, lipids and nitrogen compounds. The most important synthesis and degradation pathways for each of them will be studied: the reactions that compose them, their regulation, the organs or cellular organelles in which they take place. Finally, the last of the sections will be dedicated to the study of the integration of the various metabolic pathways studied, depending on the different organs where they take place and on different physiological and pathophysiological situations. Throughout the course, the relationship between the study of metabolic pathways and the reactions involved in them and the pathological implications of alterations in these reactions (innate errors of metabolism) will be sought.

GOAL

The objective of the course of Metabolic Biochemistry is to provide students with the necessary tools to acquire the essential knowledge related to the biochemical pathways used by the cell to obtain energy and build the biomolecules it requires to maintain its proper homeostasis.

The specific aims of the subject are:

Learn the main metabolic routes

Learn the main mechanisms for regulating metabolic pathways.

Learn how some metabolic pathways are integrated with others, their location in organs and systems in higher organisms.

Learn to carry out experiments related to the theoretical knowledge acquired in the subject and the interpretation of the results derived from them.

PRIOR KNOWLEDGE

In order to successfully face the subject, it will be necessary to have basic knowledge of the nature, composition and structure of the main biomolecules that will participate in the metabolic pathways that will be studied. In this way, it would be estimable if the student had successfully passed the course of Fundamentals of Biochemistry.
On the other hand, a minimum knowledge of Organic Chemistry (which should have been achieved in the course of Organic Chemistry, taken in the first year of the degree) will help to understand the mechanisms of those reactions that are part of the metabolic pathways that will be studied.
In conclusion, successfully passing the subjects of Foundations of Biochemistry and Organic Chemistry, although not an indispensable requirement, will help to obtain an appropriate understanding of the subject Metabolic Biochemistry.

COURSE SYLLABUS

The contents of the subject of metabolic biochemistry are essentially: Metabolism and Bioenergetics. Carbohydrate metabolism. Citric acid cycle and oxidative phosphorylation. Lipid metabolism. Metabolism of nitrogen compounds. Metabolism integration: metabolic regulation. These contents will be developed in the following topics, as described below.
INTRODUCTION TO CELLULAR METABOLISM. Catabolism and Anabolism. Levels of metabolic organization. Thermodynamic fundamentals. Coupled systems. ATP and other activated metabolites.
METABOLIC REGULATION MECHANISMS. Basic mechanisms of regulation of metabolism. Compartmentalization. Ligand binding to orthosteric enzymatic centers. Allosteric regulation. Transcription control. Hormonal control.
CARBOHYDRATE METABOLISM I: ANAEROBIC CATABOLISM. Glycolysis. Anaerobic destinations of pyruvate: Fermentations. Stoichiometry and energy balance. Regulation of glycolysis. Incorporation of other sugars into the glycolytic route. Reserves and distribution of glycogen in the body. Mobilization and degradation of glycogen. Regulation of glycogen degradation.
CARBOHYDRATE METABOLISM II: AEROBIC CATABOLISM AND OXIDATION PROCESSES. Pyruvate oxidation. Citric acid cycle. Stoichiometry and energy balance. Regulation of the citric acid cycle. Anaplerotic and cataplerotic reactions.
ELECTRONIC TRANSPORT AND OXIDATIVE PHOSPHORYLATION. The mitochondria. Redox reactions. Electronic transport through the respiratory chain. Oxidative phosphorylation and ATP synthase. Transport systems through the mitochondria (metabolic shuttles). Energy performance of oxidative metabolism.
CARBOHYDRATE METABOLISM III: THE PENTOSE PHOSPHATE ROUTE. Pentose phosphate route. Oxidative and non-oxidative phases. Generation and utilization of NADPH. Regulation of the route.
CARBOHYDRATE METABOLISM IV: ANABOLISM. Gluconeogenesis. Regulation of gluconeogenesis. Stoichiometry and energy balance. Interrelation of glycolysis and gluconeogenesis. Cori cycle. Glucogenolysis-gluconeogenesis interaction.

LIPID METABOLISM I: CATABOLISM OF FATTY ACIDS AND TRIACYLGLYCEROLS. Digestion and absorption of fats or triacylglycerols. Lipoproteins and their metabolism. Mobilization of fats and cholesterol in the body. Transport of fatty acids to mitochondria. Beta-oxidation of fatty acids. Stoichiometry and energy balance of beta-oxidation. Regulation of beta-oxidation.
LIPID METABOLISM II: ANABOLISM OF FATTY ACIDS AND TRIACYLGLYCEROLS. Fatty acid biosynthesis. The acyl carrier protein (ACP). Fatty acid biosynthesis reactions. Regulation of fatty acid biosynthesis. Biosynthesis of fats or triacylglycerols.
METABOLISM OF NITROGEN COMPOUNDS. AMINO ACIDS. Nitrogen fixation (nitrogen cycle in the biosphere). Degradation of amino acids. Amino acid deamination reactions. The urea cycle. Amino acid biosynthesis. Amino acids as biosynthetic precursors.
METABOLIC INTEGRATION AND METABOLISM OF THE MOST IMPORTANT ORGANS. Endocrine regulators, families and main structural and functional characteristics. Hormonal regulation of metabolism in different organs. Interdependence between the main organs involved in metabolism. Adaptation to different metabolic situations.
INTERNSHIP CREDITS: Laboratory Practices. Several laboratory practice sessions have been scheduled to deepen some of the concepts explained during the theory sessions, with an emphasis on enzyme kinetics and its regulation. The schedule and scripts for these practices will be announced in due time on the corresponding page in the Virtual Classroom for the subject.

EDUCATION ACTIVITIES

The training activities of the subject will consist of:
- Participatory exhibition classes. The participatory expository classes of the subject of Metabolic Biochemistry will make use of various methodologies in order to achieve the proposed objectives. An important part of them will consist of master classes in which the theoretical foundations of the subject will be established. Classes will also be organized to ask questions about topics previously proposed by the teacher. In the virtual classroom of the subject, consultation and study materials (slides used during classes, videos, bibliography) will be made available to students to facilitate work by the student, individually or in groups.
- Practical classes: real experiments will be carried out in teaching laboratories where techniques and knowledge related to the subjects of the module will be applied. The detailed content of the practices and their schedules for each group will be published in due course in the virtual classroom of the subject by the teacher responsible for the practical classes
- Tutoring: through tutoring, the teacher, at the request of the student and at the established time for this purpose, will answer questions or discuss the questions posed to him by the student, in order to guide him in learning the subject and consolidating knowledge.
- Evaluation: evaluation tests will be carried out, as detailed below
-Autonomous study: theoretical study and preparation of face-to-face activities and practical classes. Review and understanding of the experiments carried out in practical laboratory classes. Preparation of the issues to be raised and discussed in tutorials and seminars.
-Virtual network work: use of complementary materials designed in virtual network spaces, such as presentations, videos, scientific publications

DISTRIBUTION OF WORK TIME

TEACHER-LED TRAINING ACTIVITIES	INDIVIDUAL WORK

60 Horas	90 Horas

SKILLS

Basic Skills

Students must have demonstrated knowledge and understanding in an area of study that is founded on general secondary education. Moreover, the area of study is typically at a level that includes certain aspects implying knowledge at the forefront of its field of study, albeit supported by advanced textbooks

Students must be able to apply their knowledge to their work or vocation in a professional manner and possess skills that can typically be demonstrated by coming up with and sustaining arguments and solving problems within their field of study.

Students must have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgments that include reflections on pertinent social, scientific or ethical issues

Students must be able to convey information, ideas, problems and solutions to both an expert and non-expert audience

Students must have developed the learning skills needed to undertake further study with a high degree of independence

To have acquired the ability for analytical, synthetic, reflective, critical, theoretical and practical thought.

To be able to plan time effectively.

To develop capacity for and a commitment to learning and personal development.

General Skills

To have acquired the ability for analytical, synthetic, reflective, critical, theoretical and practical thought.

To be able to plan time effectively.

To develop capacity for and a commitment to learning and personal development.

Specific skills

Understand and know the fundamentals of biochemistry and molecular biology that direct the biological and physiological processes of living organisms.

Know the mechanisms and kinetics of enzymatic reactions, as well as their regulatory mechanisms.

Describe the metabolic reactions that take place in living organisms and the bioenergetics of the associated

biochemical processes.

Organize and plan the work in the laboratory correctly.

Know how to describe, quantify, analyze and critically evaluate the results obtained from experimental work carried out in the laboratory.

Develop habits of rigorous thinking.

LEARNING RESULTS

Identify the substrate structures and products of some specific metabolic pathways to be determined by the teacher.

Relate the enzymes to the corresponding substrates and products for each of the metabolic pathways studied throughout the program.

Calculate the energy performance of each of the metabolic pathways being studied.

Identify the regulatory factors to which the enzymes that control each of the reactions of the metabolic pathways being studied are subject.

Interrelate the metabolic pathways studied with the different organs of higher organisms where they take place.

Describe some of the pathologies related to metabolic defects in human beings.

Identify basic elements related to laboratory procedures focused on the study of metabolism.

LEARNING APPRAISAL SYSTEM

ORDINARY EVALUATION SYSTEM. The evaluation system, based on continuous evaluation, distributes the final grade of the subject into several sections, including the evaluation of the theoretical knowledge acquired by the student with the different methodologies used in participatory expository classes, the score obtained in the evaluation of the practical classes and the score obtained in the evaluation exercises proposed by the teacher throughout the course. In more detail, the ratings will be distributed as follows:
- Evaluation of the theoretical content of the subject: 80% (RA1, 2, 3, 4, 5, and 6 will be evaluated).
- Evaluation of the experimental work carried out in university laboratories: 20% (RA 7 will be evaluated, through content examination and/or preparation of a laboratory notebook).
With regard to the evaluation of participatory expository classes (theoretical content of the subject), written exams may consist of test-type questions and/or short questions and/or questions of development, of reasoning, of the relationship of concepts of the different subjects, of the integration of the knowledge acquired in the different training activities that will be developed in the subject.
With regard to the evaluation of practical classes (laboratory practices), their attendance is mandatory and the results obtained and the knowledge acquired in them will be evaluated through an internship exam, which will

consist of test-type questions and/or questions of short development. Practical work constitutes 20% of the final grade of the subject.
The following will be an essential requirement to pass the subject:
1) pass the written evaluation of the theoretical content, with a grade equal to or greater than 5.
2) attend each and every laboratory practice
3) pass the evaluation of practical classes (of the experimental work carried out in the laboratory), with a grade equal to or greater than 5. If these requirements are not met, the student will not pass the call.
If in the ordinary call, the student has met any of these three requirements but not all of them, the qualifications of those parts that he had passed will be maintained for the extraordinary call, having to pass in an extraordinary call only those parts that he could not pass before. The notes of the practical classes (approved) will also be kept during the following academic year, unless the student wishes to repeat the practices and the corresponding exam.
ALTERNATIVE EVALUATION SYSTEM (only for students with academic exemption from attending face-to-face participatory expository classes). Students who enroll for the second or more times in the course will be evaluated with the same criteria described above. In any case, students in second or subsequent enrollment must contact the teacher to request exemption from attending face-to-face classes.
PLAGIARISM, as well as the use of illegitimate means in evaluation tests, will be sanctioned in accordance with the provisions of the Evaluation Regulations and the University's Coexistence Regulations.

ETHICAL AND RESPONSIBLE USE OF ARTIFICIAL INTELLIGENCE

1.- The use of any Artificial Intelligence (AI) system or service shall be determined by the lecturer, and may only be used in the manner and under the conditions indicated by them. In all cases, its use must comply with the following principles:
a) The use of AI systems or services must be accompanied by critical reflection on the part of the student regarding their impact and/or limitations in the development of the assigned task or project.
b) The selection of AI systems or services must be justified, explaining their advantages over other tools or methods of obtaining information. The chosen model and the version of AI used must be described in as much detail as possible.
c) The student must appropriately cite the use of AI systems or services, specifying the parts of the work where they were used and describing the creative process followed. The use of citation formats and usage examples may be consulted on the Library website(https://www.ufv.es/gestion-de-la-informacion_biblioteca/).
d) The results obtained through AI systems or services must always be verified. As the author, the student is responsible for their work and for the legitimacy of the sources used.
2.- In all cases, the use of AI systems or services must always respect the principles of responsible and ethical use upheld by the university, as outlined in the Guide for the Responsible Use of Artificial Intelligence in Studies at UFV. Additionally, the lecturer may request other types of individual commitments from the student when deemed necessary.
3.- Without prejudice to the above, in cases of doubt regarding the ethical and responsible use of any AI system or service, the lecturer may require an oral presentation of any assignment or partial submission. This oral evaluation shall take precedence over any other form of assessment outlined in the Teaching Guide. In this oral defense, the student must demonstrate knowledge of the subject, justify their decisions, and explain the development of their work.

BIBLIOGRAPHY AND OTHER RESOURCES

Basic

Christopher K. Mathews, K.E. Van Holde, Dean R. Appling, Spencer J. Anthony-Cahill. Biochemistry/4th edition.

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coordinator: José María Teijón Rivera... [et al.]. Foundations of Metabolic Biochemistry/4th ed. Madrid:Tebar,2017.
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